# Hands-On Exploration of Dual-Turntable Rig Assembly Process

Well, what am I trying to accomplish here?.

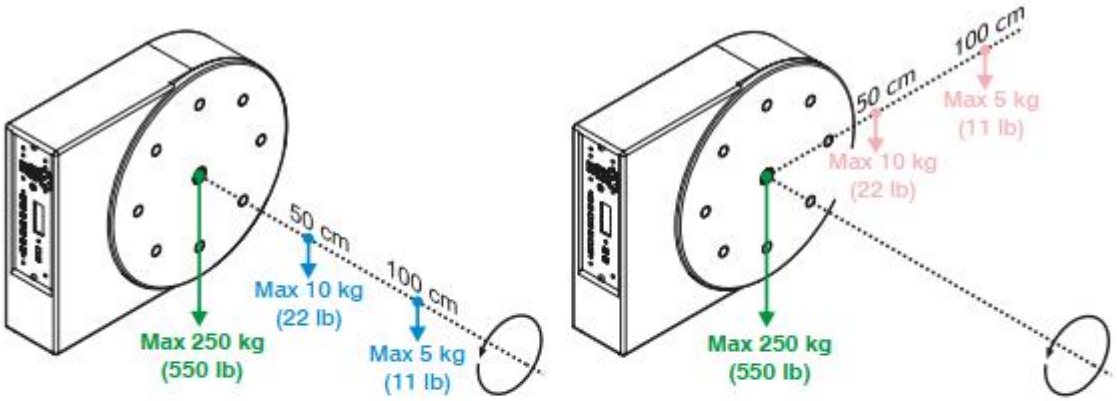
The short answer is:  I would like to see (**yes, to see**) the sound-field generated by my loudspeaker. This can be accomplished by using full spherical measurements, using two turntables – balloon measurements.

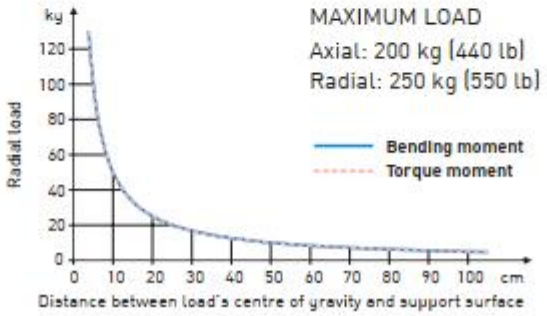
One of the most recognized loudspeaker turntables has been provided by Outline, and it is ET50-3D turntable. So, how good is this turntable?. Shown below are the specifications of the ET50. It would be beneficial to review the basic parameters the ET50 to understand if the turntable I was trying to assembly is any good at all - well by comparison. No doubts, The ET50  is a robust turntable, as you can see below. However, the specification that finally determines if turntable will do the job is the torque. Here, the torque is 50Nm.

ET SERIES — Outline

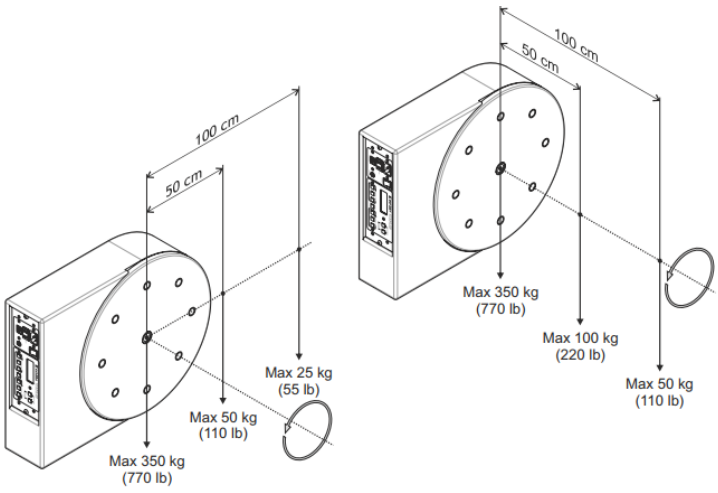
| ROTATION DATA | |
|---|---|
| Mounting Condition | Horizontal, Vertical, Upside-down |
| Drive System | Irreversible worm gear |
| Direction | Clockwise or counter-clockwise |
| Max speed (tolerance ±10%) | 1.75 RPM |
| Max Axial Load (only in compression) | 200 kg (440 lb) |
| Max Axial Load (upside-down) | 40 kg (88 lb) |
| Max Radial Load | 250 kg (550 lb) |
| Max Torque | 5 kgm (50 Nm) |
| Max Bending Moment | 5 kgm (50 Nm) |
| Resolution | 0.5° |
| Acceleration and Max Speed | Microprocessor-controlled |
| **CONTROL** | |
| Local | TTL pulse input and output |
| Remote | Standard Ethernet Protocol |
| **PHYSICAL** | |
| Chassis Material | Scratch-Resistant Painted Wood |
| Rotating Disc Diameter | 350 mm - 13 3/4" |
| Top Mounting Holes | 8 x M8 on 244 mm Diameter + 1 x M20 |
| Bottom Mounting Holes | 8 x M8 on 244 mm Diameter (on chassis) |
| Height | 107 mm - 4 1/2" |
| Width | 350 mm - 13 3/4" |
| Depth | 455 mm - 17 7/8" |
| Weight | 13.8 kg (30.4 lb) |
| Colour | Black & Grey |
| **POWER REQUIREMENTS** | |
| Mains supply | 90/250 V AC - 50/60 Hz |
| Room Temperature | From -5° to 45° C |

# ET50-3D

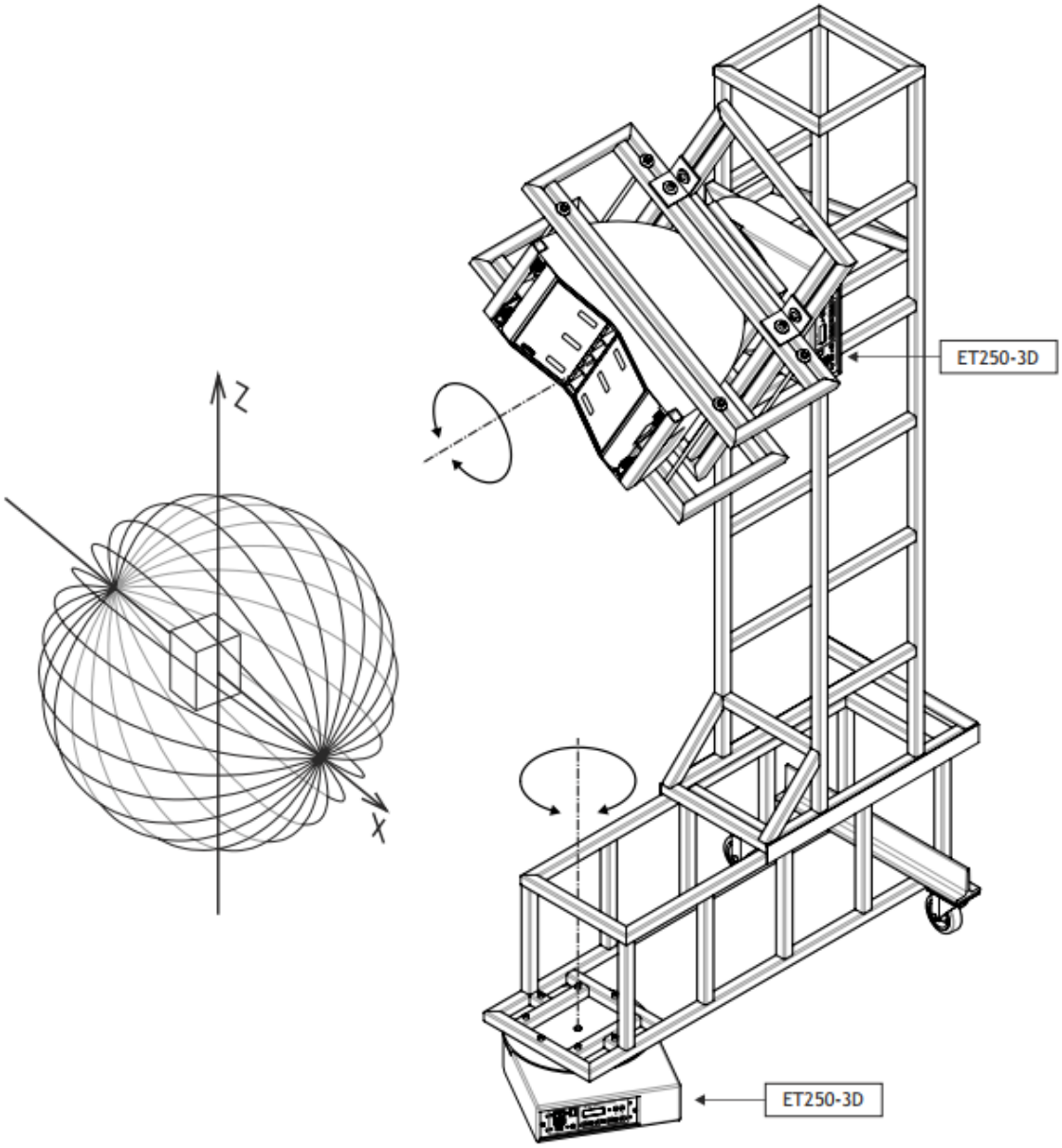



There is also a bigger version of the ET50 - it is ET250.



As one can see from the torque specification above, the ET250 is 5 times stronger than ET50. The balloon measurement rig shown below is quite massive. You will need something like that if run large loudspeaker company and built commercial loudspeaker systems for outdoor applications. And can afford to spent $20k-$40k on such rig. Fortunately we, the DIY bunch, are not requiring such equipment.




## Torque Considerations

I have been unable to find clear torque specifications for the turntable rig I am trying to assemble. This is unfortunate, as the torque is the essential parameters, based on which one should determine if this device is actually suitable for the intended application.

However, after some digging on the internet, I found the following information about the motor and the gearbox.

**PG20-100 Harmonic Reducer Gearbox, Gear reduction is 100:1**
https://www.aliexpress.com/item/1005006518985947.html


**PG20-100**
Reduction ratio: 100
Rated torque when inputting 2000r/min: 40 Nm
Allowable peak torque when starting and stopping: 82 Nm
Allowable maximum value of average load torque: 49 Nm
Momentary allowable maximum torque: 147 Nm
Allowable maximum input speed: 6500
Allowable average input speed: 3500
Moment of inertia: 0.193
Backlash: 10ASD

https://en.bonsystems.com/motor-gearbox-torque-calculation/

From the above website:

**Output Torque = Motor Rated Torque × Gear Ratio × Gearbox Efficiency**

**I assume Gearbox Efficiency = 100%  Therefore:**

Motor Rated Torque = Output Torque/Gear ratio

On PG20-100 here we find the allowable maximum value of average load torque (I assume, that this is output torque) as 49Nm. Since the gear ratio is 100:1, the maximum input (Motor Rated) torque would be:

49Nm/100 = 0.49Nm

From the Stepper Motor specification, we find Rated Continuous Torque = 0.87Nm. It appears, that the CM1 motor can provide more than adequate input torque into the gearbox.

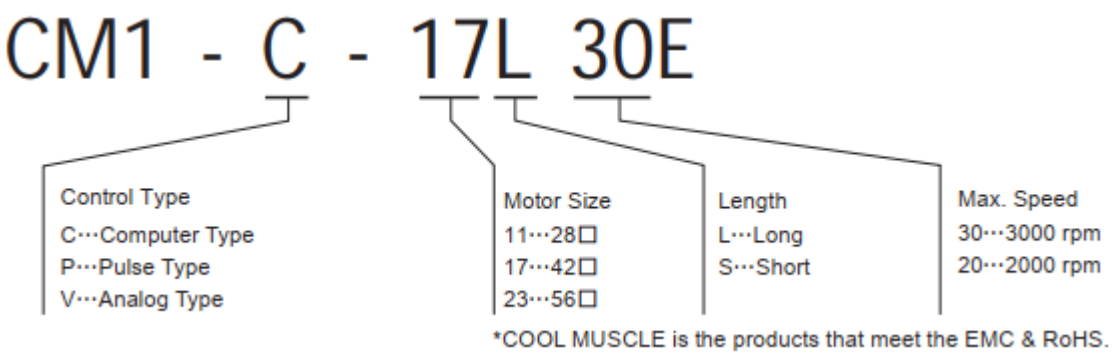
0.87Nm > 0.49Nm

And there is indeed a significant safety margin left, and thus created system will meet the 49Nm output torque specifications. Not far from ET50 specs.

Well, I would love to see the above confirmed by a mechanical engineer, which I am not.

**CM1 – C – 23L20E**  Stepper Motor Specification

https://musclecorp.com/motion-control/product/cm1/



# COOL MUSCLE Specifications

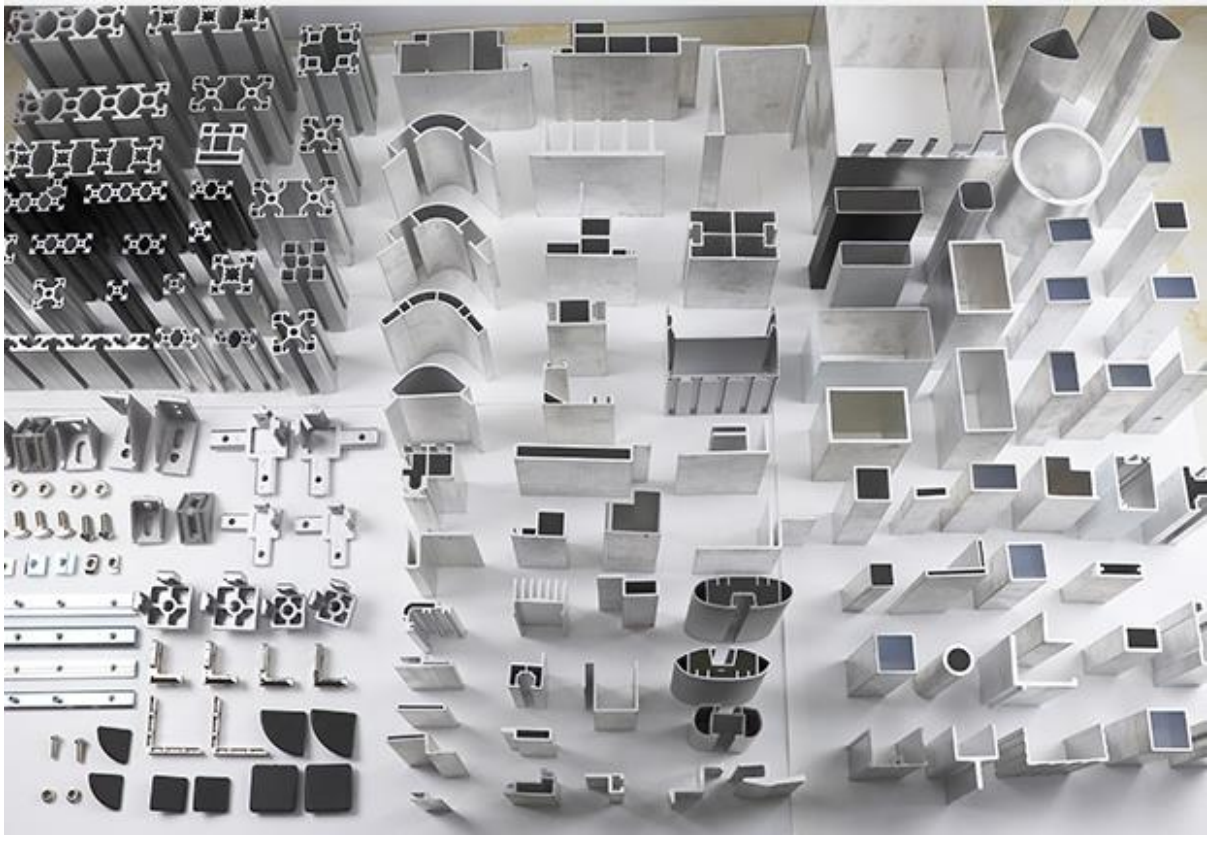
| Specification | CM1-☐-11 | | CM1-☐-17 | | CM1-☐-23 | |
|---|---|---|---|---|---|---|
| | -L30 | -S30 | -L30 | -S30 | -L20 | -S30 |
| Motor Output Power | 18W | 9W | 18W | 18W | 30W | 45W |
| Max. Speed | 3000rpm | 3000rpm | 3000rpm | 3000rpm | 2000rpm | 3000rpm |
| Rated Continuous Torque Kgfcm(Nm) | 0.56 (0.055) | 0.28 (0.027) | 3.7 (0.36) | 0.84 (0.082) | 8.9 (0.87) | 3.0 (0.29) |
| Rated Peak Torque Kgfcm(Nm) | 0.80 (0.078) | 0.40 (0.039) | 5.3 (0.52) | 1.2 (0.12) | 12.7 (1.24) | 4.3 (0.42) |
| Load Inertia Allowance $gcm^2$ | 180 | 80 | 760 | 380 | 4600 | 1400 |
| | Depending on the load inertia, servo gain needs to be adjusted within the above range: adjustable by parameters | | | | | |
| Motor Inertia $gcm^2$ | 18 | 8 | 74 | 36 | 360 | 100 |
| Allowable Radial Load [N](kgf) distance from the mounting surface | 4.9 (0.50) 15 | 4.9 (0.50) 15 | 34 (3.5) 18 | 37 (3.8) 18 | 70 (7.1) 20.6 | 77 (7.9) 20.6 |
| Allowable Thrust Load [N](kgf) | 9.8 (1.0) | 9.8 (1.0) | 10 (1.0) | 10 (1.0) | 15 (1.5) | 15 (1.5) |
| Encoder | Incremental Magnetic Encoder(50000 pulses/Rotation) | | | | | |
| Control Method | Closed Loop Vector Control | | | | | |
| Input Supply Voltage | DC24V±10% | | | | | |
| Input Supply Current Rated (Continuous/Rated Peak) | 1.2A/1.5A | 0.8A/1.0A | 1.5A/1.8A | 0.8A/1.0A | 2.6A/3.4A | 3.9A/5.1A |
| Relosution Pulse Rotation (Pulse/Rotation) | From 200 to 50000 Set by parameter | | | | | |
| Environmental Conditions Operation/Storage | 0℃~+40℃/-20℃~+60℃ No condensation condition | | | | | |
| Operative Humidity | Less than 90% RH | | | | | |
| Impact/Vibration | Less than 10G/Less than 1G | | | | | |
| Weight (Approx.) | 300g | 240g | 480g | 330g | 1100g | 550g |

# Aluminium Components

Aluminium Extrusions

These are found and available from many sources. One example is shown below. The skeleton of the rig and side-feet are constructed from those extrusions.

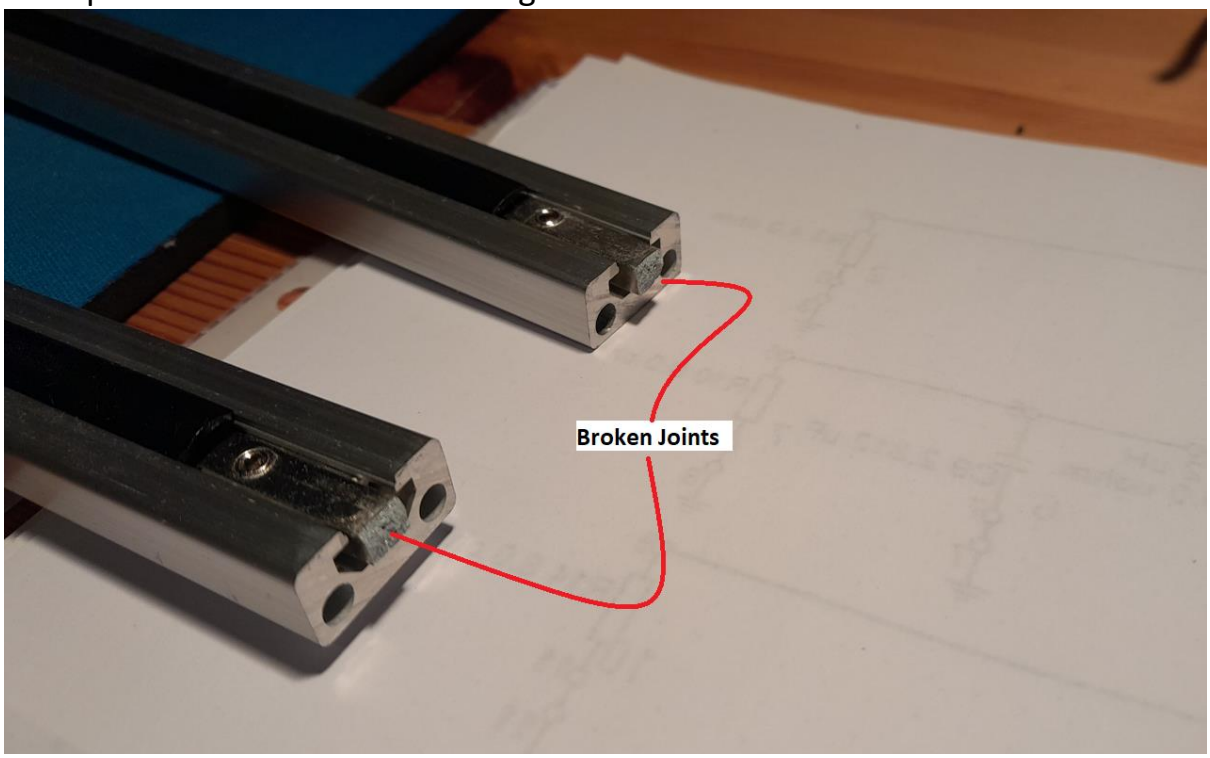
https://www.hy-aluminum.com/products/extruded-profile/customized-aluminum-profile-factory.html

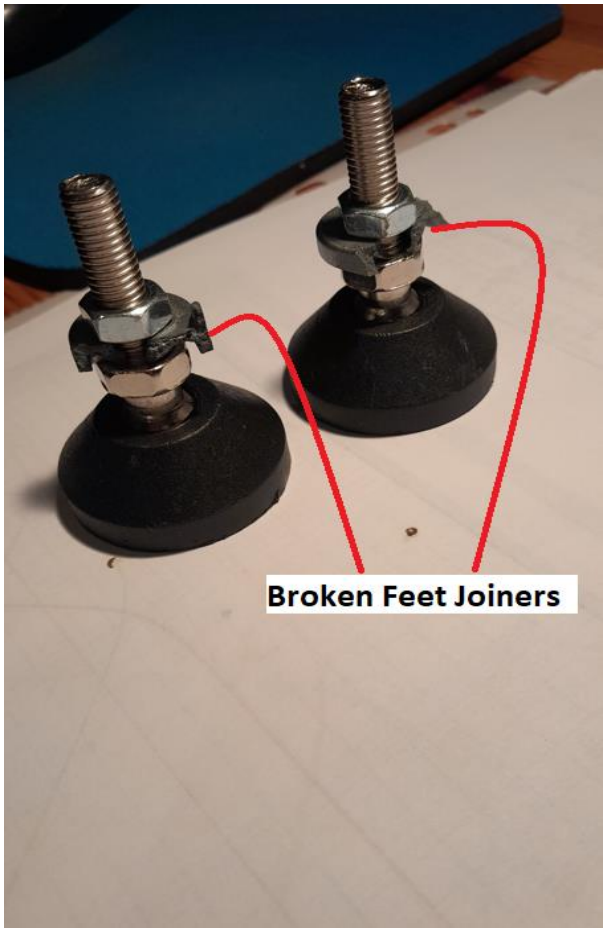


You will find, that the supplier of profiled aluminium extrusions would typically also supply connectors/joiners, and specialized nuts and bolts – as you can see on the picture above. The joiners and screws are on the bottom-left corner of the picture above.

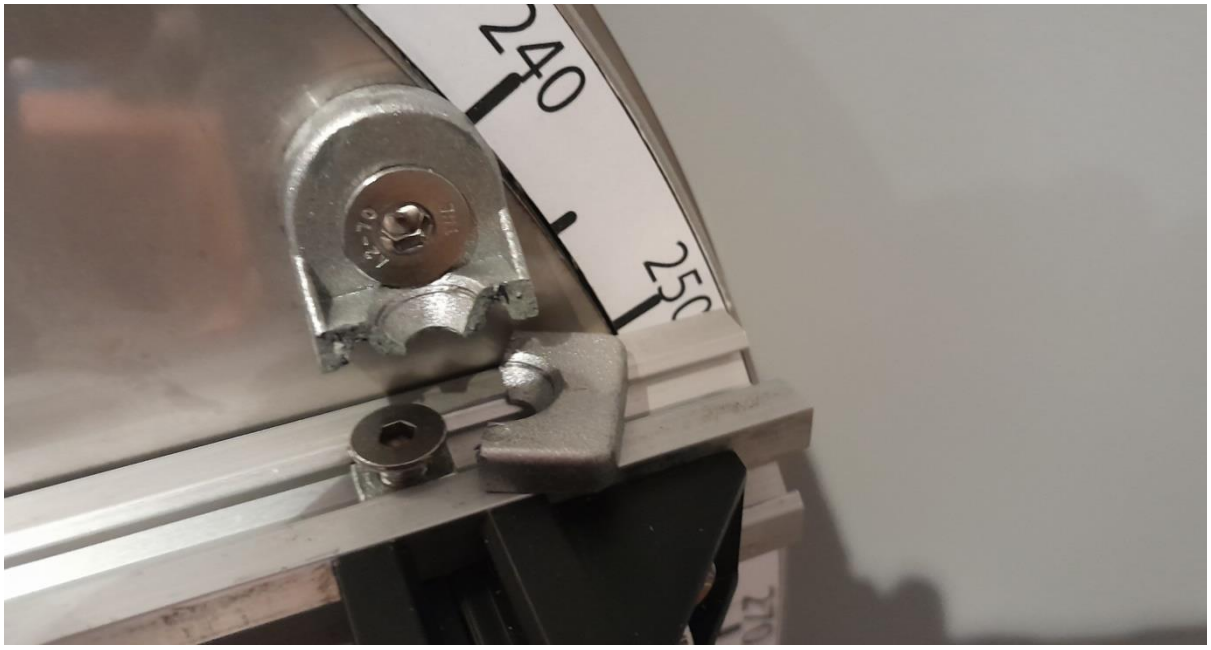
During my assembly process, I have very quickly discovered, that some extrusions, and particularly joiners, were way too weak for this job. A number of joiners broke, and had to be replaced with much stronger versions. I am showing several examples below, so you can avoid my mistakes.

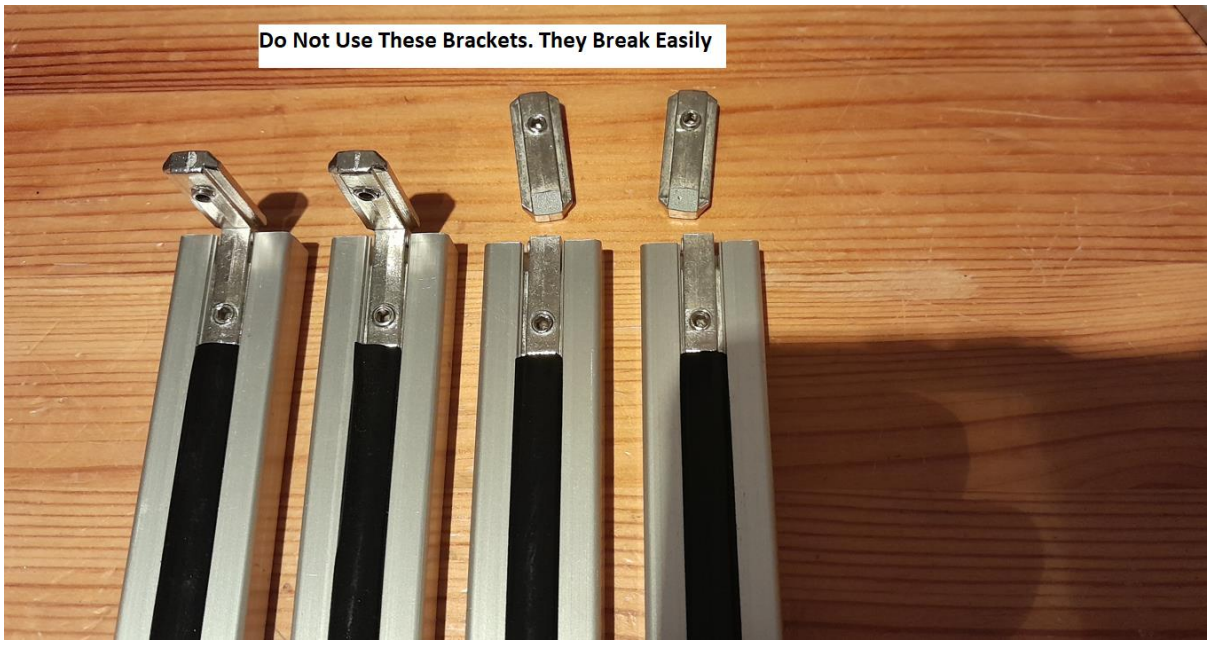
The extrusions and joiners shown below would not hold even the smallish loudspeaker I have used for testing.



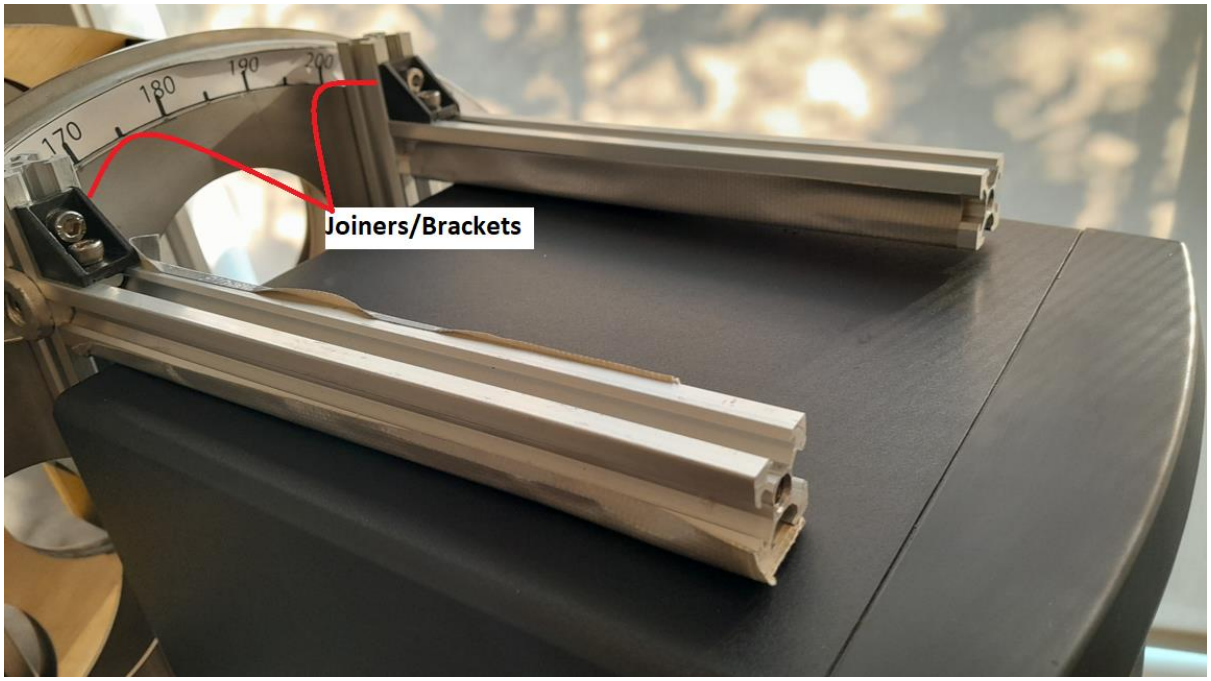

The joiners shown below were also cracking easily. When you look closely, there is not much metal around the screw bed, even though the whole joiner looks robust.



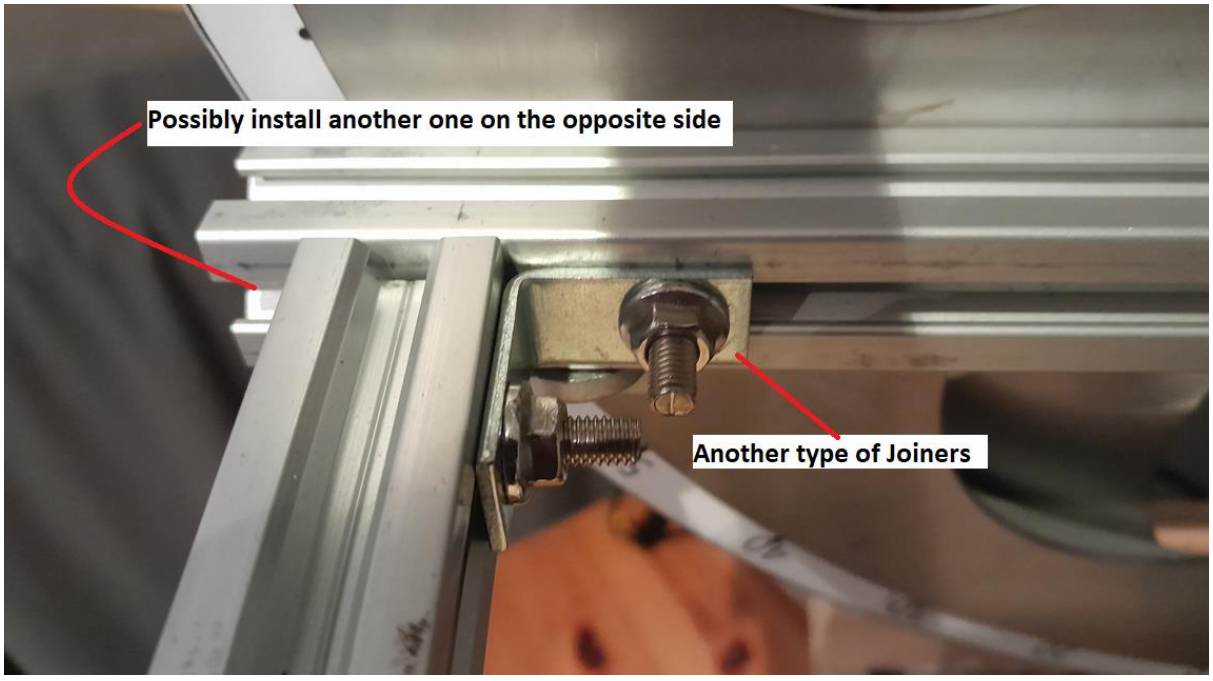




So, as you can see, it wasn't "smooth sailing" with this project at all. These experiences prompted me to expose the problems and mistakes I made. I am guessing here, but quite possibly an experienced mechanical engineer would knew right away what to do.

The extrusion profile shown below and the joiners have proven to be much better choice. Using those, I was able to finally assemble my rig and start testing the loudspeaker. My loudspeaker weight was under 6kg.

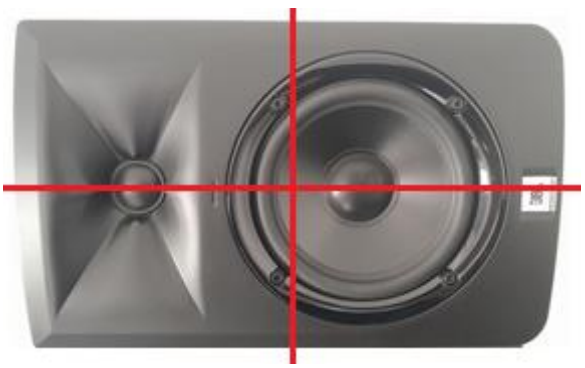



The joining brackets shown below are available from my local hardware store. They work very well indeed and are quite possibly the strongest option to consider, if you use two of them, on the opposite sides of the extrusion.

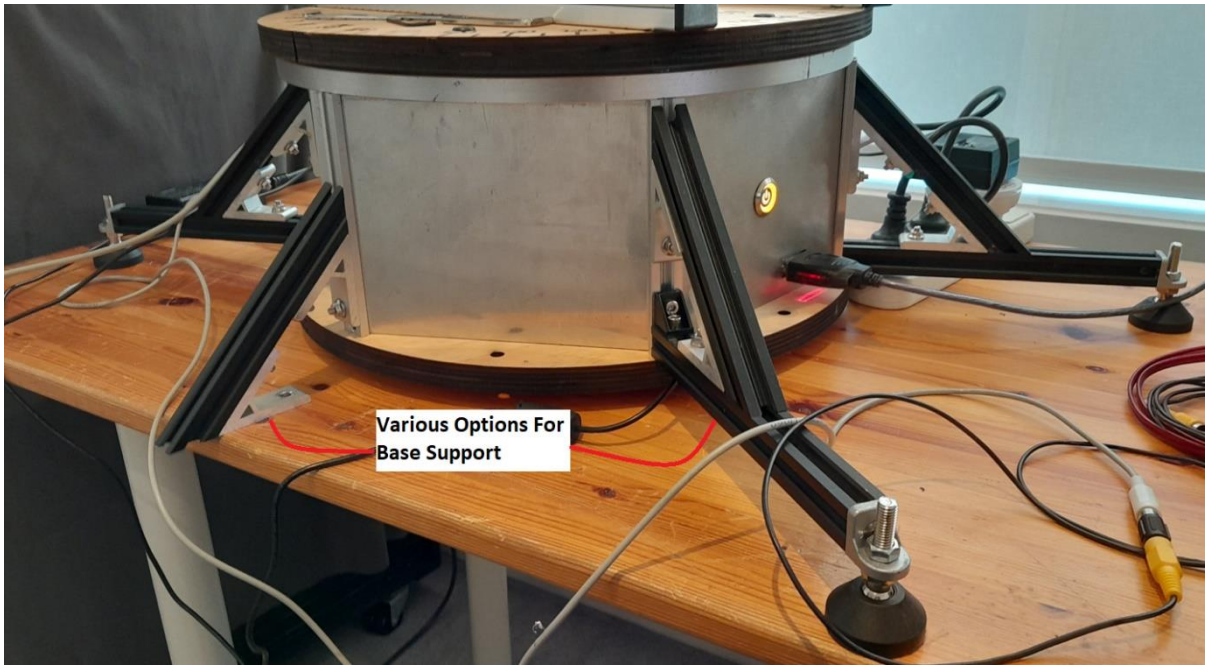



## Supporting Feet

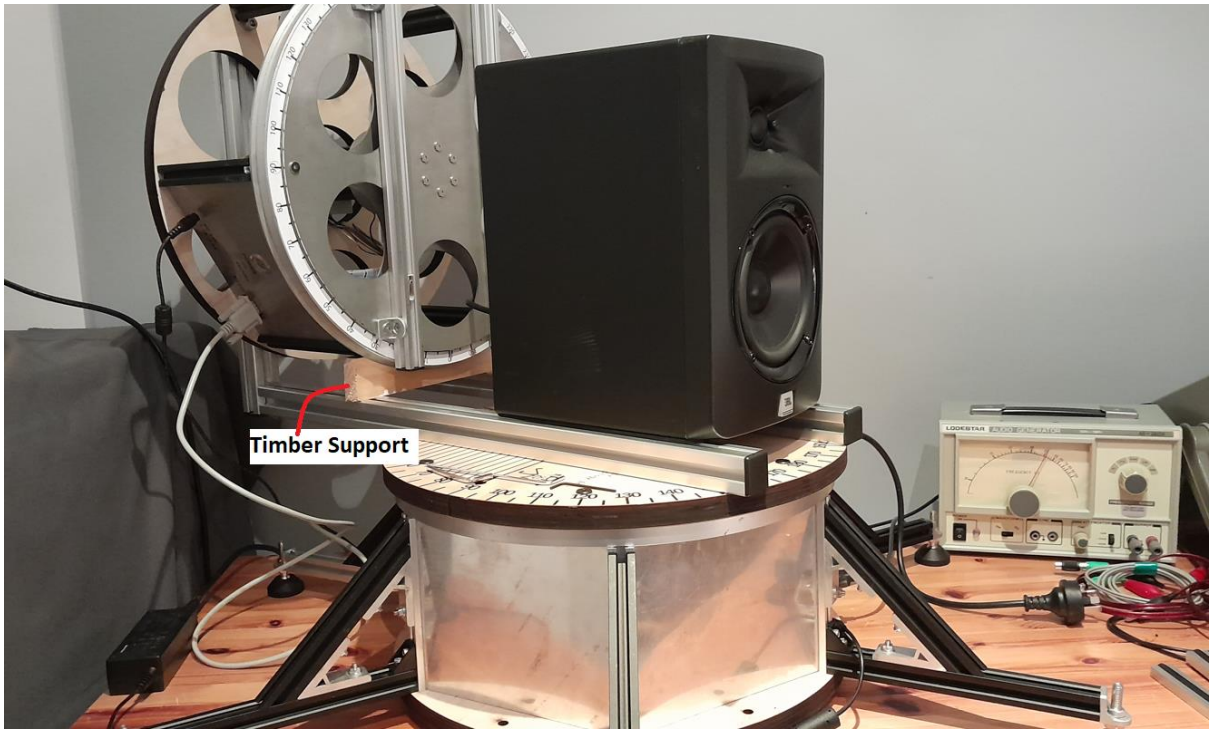
As shown below, there are a few ways you can implement the supporting feet. Their size and length could be determined by the size of the loudspeaker box and its weight. Please note, that the loudspeaker needs to be attached with its geometrical front baffle centre co-located with the centre of rotation of the dual-turntable system. So, that weight will be quite balanced, but not completely, as the bottom of the loudspeaker box is typically heavier than the top-side.

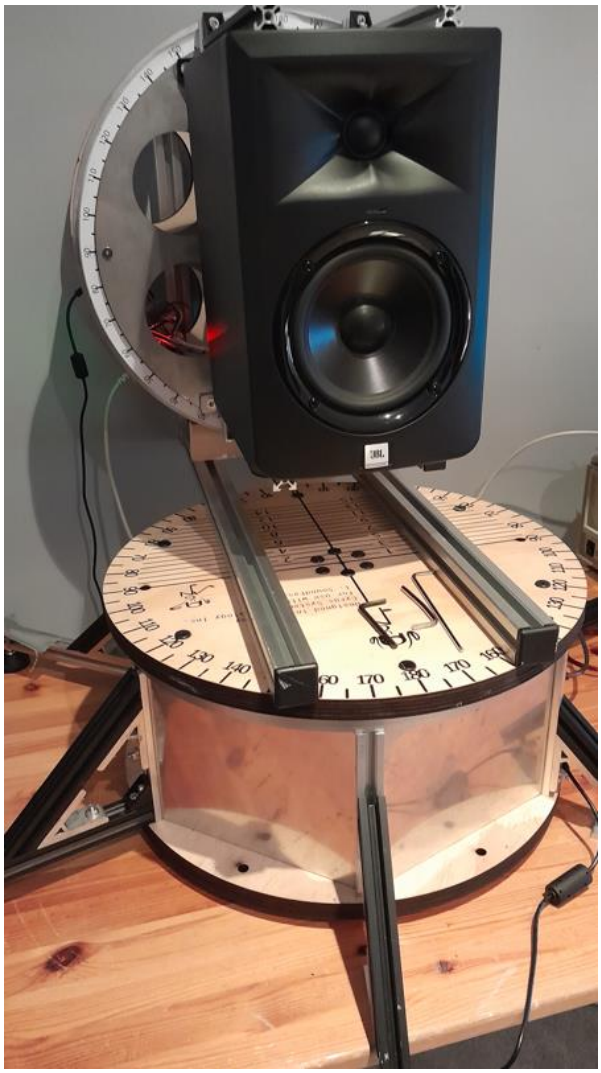


Please note, that the loudspeaker mounting for balloon tests is somewhat different than for ANSI-CTA tests. Loudspeaker mounting is more balanced and in many instances, balloon tests would not require supporting wheels – just some feet arrangement to keep the whole rig stable.




And finally, fully assembled, small rig used for software development and testing is shown below. Please note, that at some point of measurements, the loudspeaker will be turned side-ways. I used a duct-tape to prevent the loudspeaker from slipping off the extrusions. But some small brackets attached to the horizontal extrusions would be a better choice.


Timber Support

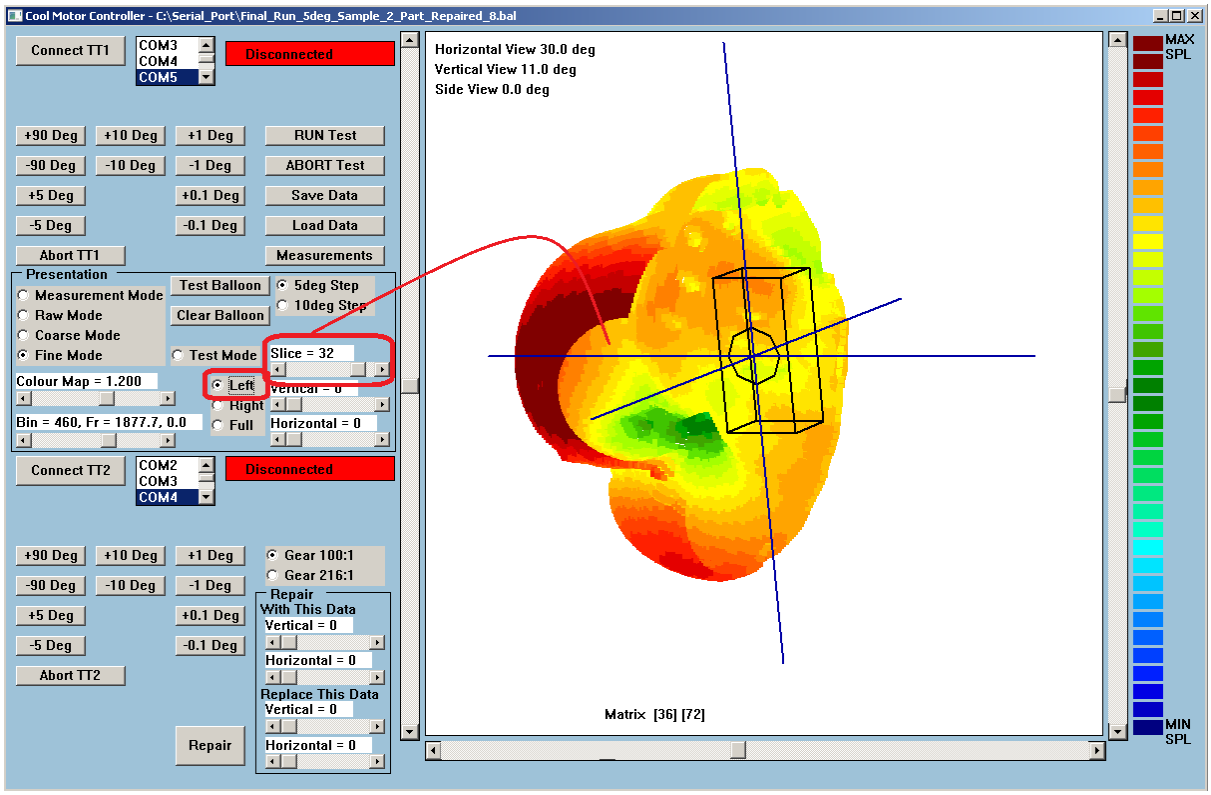


# Is it worth the effort ?

## Advancement of NEW DIY Tools

Firstly, consider the opportunity of putting your hands on the equipment, which until now, was only available for loudspeaker design engineers working for multi-million dollar companies. Now, it is here and available.

This rig brings the opportunity to visualize the sound-field generated by the loudspeaker system into the DIY community. As a staring example, it will allow you to make full comparison of the sound-fields generated by CD tweeters vs. Dome tweeters. And obviously so much more….




The rig is scalable. One can start with single turntable and enjoy the benefits of having ANSI-CTA-2034 automated tests performed with SoundEasy software.
In the next step, the second turntable will finalize the full dual-turntable rig.

The controlling software is available free of charge for all SoundEasy users, who are in the possession of the dual-turntable rig. The software provides all functionality needed for controlling two turntables, all MLS measurement functions and several advanced additional processing options. All that you would expect to perform advanced measurements in semi-reflective acoustical environment.

**Economical Factors**

Consider the cost of several reputable loudspeaker drivers, available from Parts Express:

Aurum Cantus AC300/75C2C 12" Woofer

6 Reviews

**$324.98**

Morel TiCW 1258Ft Titanium Series 12" Subwoofer 8 Ohm

2 Reviews

**$848.00**

Visaton TIW300-8 12" High-End Woofer 8 Ohm

0 Reviews

NEW **$395.98**

Aurum Cantus AC165/50C2C 6-1/2" Midwoofer

4 Reviews

**$156.98**


Morel ET 448 1-1/8" Soft Dome Tweeter

8 Reviews

**$170.00**

Jantzen Audio 3.5mH 18 AWG Air Core Inductor Crossover Coil

6 Reviews

**$20.31**

Then add the rest of the crossovers, all necessary timber, glue, screws, wiring, feet, terminals, paint or finish costs and so on…….

A $1000 per box doesn't seem to far from the real costs, and can easily exceed $1500. Then try to build a 5.2 HT system with good drivers. Hey, what about the amplifiers and the rest of it?.

I have not built a really expensive speaker. The most expensive speaker I have ever constructed was a subwoofer with McCauley 18" 6174 drivers. I have two of them for a total cost of $2500 at the time. The whole system is described in: https://www.bodziosoftware.com.au/Home_Theatre_Conclusions.pdf

The cost of the total system exceeded $6000, and this includes a HTPC with two soundcards and two multichannel amplifiers. Ever since then, this system evolved and changed, further increasing the costs.

Obviously, economical factors are very individual, so I am just offering one perspective on it.

**Commercial Opportunity**

There are commercial opportunities associated with this project. I would assume, that you would have mechanical engineering qualifications or be passionate and skilled in mechanical issues altogether. Some business acumen would be an advantage as well.

A simple starting point would be some well design, robust rig for the single turntable option, like for ANSI-CTA-2034 measurements with SoundEasy, even if you just offer your build plans of the rig to the DIY community. My little rig was not acoustically transparent enough, because the top turntable was located too close to the bottom turntable. Well, here is an opportunity for the clever mechanical person to do it better. And you can take this as far as you feel. Maybe one day you will create your own turntables. Wouldn't that be something?....

There are things to consider like, size and weight of the targeted loudspeakers, acoustical issues, balancing, extra feet and so on. Your expert knowledge and experience could help your fellow designers in their quest to enhance their loudspeakers. Bodzio Software will work with you on the software side to achieve your goals in this field.

So, if you contemplate stepping out from being the user of somebody's creation – to actually create/contribute your own skills to the DIY community – I'll take my hat off to you.

This is my short account of the efforts I have undertaken to be able to visualize the sound-field of my loudspeaker.

Thank you for reading.